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PRUSSIC ACID IN PHASEOLUS LUNATUS AND OTHER BEANS[1]

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The hydrocyanic acid[2] content of the different varieties of *Phaseolus lunatus*, Linn. and other plants have been determined by chemists in Germany (1), France (2), Cuba (3), United States (4), British India (5), and Trinidad Tabago (6), but here in the Philippines investigation with reference to this subject, if any has been made, has not been published. Hydrocyanic acid, either free or as a cyanide, is deadly poisonous to men and to animals. Cases of poisoning of cattle by the leaves and pods of the wild varieties of *Phaseolus lunatus*, Linn., *sibatse simaron* (Tagalog), have been reported to the writer by farmers from Batangas and elsewhere.

A local daily newspaper[3] reported from official sources the death of two persons on January, 1922, as the result of eating *bule patani*. Five other persons who ate of the same beans were seriously ill. The beans eaten were gathered in the woods. These men were laborers employed by the Mabalacat Sugar Mills Company, Pampanga. All efforts by physicians to save the lives of the two men were in vain.

The *bule patani*, according to some students in this College from Pampanga, is the wild black variety of *Phaseolus lunatus*.

SURVEY OF LITERATURE

Simpson (3) reports that, of the many varieties examined by him, only Rangoon blanca was found to contain more than 40 milligrams of hydrocyanic acid per 100 grams of sample.

Grimme (2) reports that the colored cultivated varieties of Rangoon beans, *Phaseolus lunatus*, contain as high as 0.24 per cent hydrocyanic acid, while the white variety of commerce contains only from 6 to 12 per cent of the limiting value of 0.02 to 0.035 per cent hydrocyanic acid set by the French and German governments.

Dunbar (7) in a discussion of the HCN content of Rangoon and moon beans and the advisability of their use as food, advises excluding them from diet of children under ten years, because cooking with decantation of the liquor may remove only one half of their prussic acid (HCN) content.

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1 Thesis presented for graduation from the College of Agriculture, No. 145; Experiment Station contribution, No. 105.

2 Hydrocyanic acid is more commonly known as prussic acid. The two terms are used interchangeably in this paper.

3 *The Philippines Herald* of February 10, 1922.

a. The toxic action of Rangoon beans.—Gabel and Krüger (8) report that Rangoon beans contain from 48 to 357 milligrams HCN per kilogram, and boiling for 2 hours leaves about 24.5 per cent of the total HCN content. Beans boiled for 2½ hours, containing originally 354 milligrams per kilogram, were eaten by two persons for supper. The amount eaten was equivalent to 100 grams raw beans. One vomited at noon the next day. The urine of both persons contained about 2 milligrams HCN. Boiled beans containing, originally, 175 milligrams HCN were eaten by two persons for supper. The amount taken was equivalent to 250 grams raw beans. At noon, the same amount was eaten. There were no external symptoms of ill effect, but the urine contained traces of HCN. According to Amberg (8) France permits the sale of beans with less than 200 milligrams prussic acid (HCN) per kilogram of sample.

b. Physiological action of prussic acid on the human system (9).—

> Prussic acid first stimulates and then paralyzes the central nervous system in mammals. It acts on so many forms of living matter that it merits the designation of a general protoplasm poison. The fatal dose to man is believed to be about 0.05—0.08 g. (1-1½ gr.) of the pure acid. Prussic acid has gained its reputation of being the most dangerous of poisons.
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> After very large doses in mammals, there may be practically no symptoms; the animal falls to the ground with a slight convulsive movement or a scream, and death follows in a few seconds from simultaneous arrest of the heart and respiration.
>
> In small quantities, prussic acid has a bitter, burning taste, which is accompanied by salivation, and is followed by a numbness in the mouth and throat. A sensation of warmth in the stomach is followed by nausea and vomiting, confusion and headache, dyspnaea, slow pulse and general muscular weakness. The pupils are widely dilated and the eyeballs protrude. Unconsciousness follows, and then violent convulsions. Respiration becomes extremely slow and eventually ceases, while the heart continues to beat for some time afterwards. * * *
>
> Besides its specific action on the central nervous system, prussic acid exercises a depressant action on protoplasm in general, and may therefore be called a general protoplasm poison, although some of the bacteria are but little affected by it. Both plants and animals are retarded in their movements and in their nutritive processes by its presence, although they may recover and show no subsequent deterioration provided the poison acts only during a short time and in sufficient dilution. * * *

This paper presents the relative amount of prussic acid (HCN) found by the writer in wild, semi-cultivated, and cultivated *Phaseolus lunatus* found in the Philippines; the effect of different treatments on the removal of the poisonous acid from them; and the effect of the boiled beans on guinea pigs.

This work was conducted at the College of Agriculture, University of the Philippines, during the College year 1921-1922.

MATERIALS

1. VARIETIES ANALYSED

The following beans were tested for the presence of HCN; the wild, semi-cultivated, and cultivated *Phaseolus lunatus* Linn., mungo (Tagalog), *Phaseolus*

radiatus Linn., calamismis (Tagalog) and calamismis (Ilocano), *Psophocarpus tetragonolobus* Linn., and cowpeas, paayap (Tagalog), *Vigna sinensis* Savi.

For the purpose of the present studies, *Phaseolus lunatus* is the most important of these beans, for the others are not popularly rated as poisonous.

Phaseolus lunatus is described by Merrill (10) as follows:

> *Phaseolus lunatus*, Patani (Tagalog), is a scandant, slender, annual, glabrous or sparingly pubescent, herbaceous vine reaching a length of 4 meters or more, the stipules small, basifixed. Leaflets ovate, acuminate, thin, 6 to 12 cm. long. Racemes axillary, solitary, peduncled, 8 to 10 cm. long. Flowers long-pedicelled, about 13 mm. long, the calyx pale-greenish or pale yellowish. Pods oblong, somewhat curved, 6 to 12 cm. long, about 2 cm. wide, containing from 1 to 4 large, variously colored or white seeds.
>
> Frequently cultivated for its edible beans, flowering September to April. Cultivated in all tropical and warm countries, a native of tropical America.

Table I gives description of the varieties of *Phaseolus lunatus* analyzed for HCN by the writer. The College wild purplish brown (F_5) and the wild black (F_3) were from a wild stock but had been under cultivation in the College Experiment Station for five and three years, respectively. The wild beans, *sibatseng gubat*, from Lipa and Talisay were gathered in the woods. The semi-cultivated *sibatse* from Taal was gathered in the sugar cane fields and on an uncultivated farm. They were growing wild. All of the beans named in Table I, with the exception of the ones obtained from San Antonio, Los Baños, and the green pods from Lipa, were ripe and had been partially dried in the sun.

TABLE I.—*Varieties of Phaseolus lunatus studied.*

No.	Variety name.	Color of beans.	Source.	Remarks.
1	College wild purplish brown (F_5).	Purplish brown	Col. of Agriculture	From wild stock
2	College wild black (F_3).....	Black	Col. of Agriculture	From wild stock
3	Sibatseng gubat, or simaron....	Pale brown	Lipa, Batangas	Wild
4	Sibatseng gubat, or simaron....	Black	Talisay, Batangas	Wild
5	Sibatseng gubat, or simaron....	White	Talisay, Batangas	Wild
6	Sibatseng gubat, or simaron....	Purplish brown	Talisay, Batangas	Wild
7	Sibatseng gubat, or simaron....	Light purple	Talisay, Batangas	Wild
8	Sibatse.....	Black	Taal, Batangas	Semi-cultivated
9	Sibatse.....	White	Taal, Batangas	Semi-cultivated
10	Patani.....	Purplish gray	Taal, Batangas	Cultivated
11	Patani.....	Purplish gray	Los Baños, Laguna	Cultivated

METHODS OF ANALYSIS

1. PREPARATION OF SAMPLE

Each sample was ground in a meat grinder, powdered in an iron mortar, and then passed through a one-half millimeter mesh sieve to make the sample uniform.

2. QUALITATIVE ANALYSIS

a. Extraction and identification.—The methods employed in the analysis are, in general, those described by Warren (11), and by Guignard (12). The Guignard's simple picric reagent was prepared by dissolving one gram of picric acid in 100 cc. of distilled water and adding to the solution 10 grams of crystal-

lized potassium carbonate. The test was performed by hydrolyzing a 50-gram sample in a suitable flask with 50 cc. N/10 sulfuric acid and 400 cc. water. A filter paper dipped in the picric acid solution prepared as described above was suspended in the neck of the flask. The flask was corked tight and allowed to stand at room temperature for 24 hours. The production of an orange-red color on the picric acid paper indicated the presence of prussic acid or a cyanogenetic glucoside (HCN). This identification was confirmed by hydrolyzing a sample and extracting the prussic acid by steam distillation. The acid volatilizes readily with steam. The first 5 or 20 cc. of the distillate were tested for the presence of hydrocyanic acid by the following methods as described by Warren (11): 1, *the prussian blue test*, 2, *the sulphocyanate test*, 3, *the Vortman's nitroprusside test*, 4, *the silver nitrate test* and 5, *the picric acid test.*

3. QUANTITATIVE ANALYSIS

a. Extraction and determination.—Twenty-five grams of newly powdered sample in a two-liter distilling flask were treated with 400 cc. distilled water, and the mixture acidified with 50 cc. of N/10 sulfuric acid. The distilling flask was then connected to a condenser, the extreme end of which was attached to a one-liter receiver by a glass tube in such a way that the end of the glass tube was below the surface of the potassium hydroxide solution contained in the receiver. This arrangement was found necessary to prevent any possible loss of hydrogen cyanide gas during distillation; otherwise the loss during hydrolysis and distillation was quite appreciable as may be seen in the preliminary tests. The samples were hydrolyzed at room temperature from 18 to 24 hours and after hydrolysis the HCN was distilled with steam until about 500 cc. of distillate was collected. The receiver was immersed in a tin casserole containing ice and water to maintain the temperature of the distillate at 15°C., for hydrogen cyanide volatilizes at 25°C. The alkaline distillate was then titrated with the standard silver nitrate solution using Liebig's method (13).

EXPERIMENTAL RESULTS AND DISCUSSION

1. QUALITATIVE ANALYSIS

Table II gives the results of the qualitative determinations of the different varieties of *Phaseolus lunatus*,—the wild, the semi-cultivated, and the cultivated, and those of mungo, calamismis, and cowpea. All the varieties of *Phaseolus lunatus* gave positive results as indicated by the plus sign (+), while the other beans gave negative results, as indicated by the minus sign (—).

2. QUANTITATIVE DETERMINATION

a. Preliminary tests.—Preliminary tests were run because in running the qualitative tests it was observed that when the delivery tube of the distilling flask was connected to the silver nitrate ($AgNO_3$) solution during hydrolysis and distillation, some of the hydrogen cyanide came over and formed a grayish curdy precipitate of silver cyanide before any condensible distillate passed over. Table III gives the comparative results under different conditions. When the end of the delivery tube was immersed in the alkali solution during hydrolysis and distillation, the average amount of prussic acid per 25-gram sample hydrolysed for 18 and 24 hours was about the same, but when the distillate was just allowed to drop into the alkali solution there was a loss of 5.43 milligrams of prussic acid per 25 grams, as compared with the average of the two averages in the former determinations.

TABLE II.—*Qualitative analysis of beans.*

Names of beans.	Guignard's simple picric acid test paper.	Prussian blue test.	Sulphocyanate test.	Vortman's nitroprusside test.	Silver nitrate test.	Picric acid test.
1. College wild purplish brown sibatse (F_5)	+	+	+	+	+	+
2. College wild black sibatse (F_3)	+	+	+	+	+	+
3. Lipa pale brown sibatseng gubat	+	+	+	+	+	+
4. Talisay black sibatseng gubat	+	+	+	+	+	+
5. Talisay white sibatseng gubat	+	+	+	+	+	+
6. Talisay purplish brown sibatseng gubat	+	+	+	+	+	+
7. Talisay light purple sibatseng gubat	+	+	+	+	+	+
8. Taal semi-cultivated black	+	+	+	+	+	+
9. Taal semi-cultivated white sibatse	+	+	+	+	+	+
10. Taal purplish gray cultivated patani	+	+	+	+	+	+
11. Los Baños purplish gray cultivated patani	+	+	+	+	+	+
12. Mungo	—	—	—	—	—	—
13. Ilocano calamismis	—	—	—	—	—	—
14. Tagalog calamismis	—	—	—	—	—	—
15. Cowpea (the white, the spotted and pale brown varieties.)	—	—	—	—	—	—

TABLE III.—*Comparison of results obtained under different conditions, using College purplish brown beans* (F_5)

(Figures are in milligrams per 25-gram sample)

Number of determinations.	With end of delivery tube immersed in the alkali solution.		Allowing the distillate to just drop into the alkali solution.
	Hydrolysed 18 hours.	Hydrolysed 24 hours.	Hydrolysed 24 hours.
	milligrams.	*milligrams.*	*milligrams.*
1	13.35	15.19	9.50
2	15.19	15.32	10.00
3	15.07	15.19	9.68
4	15.19	15.07	10.06
5	15.45	15.26	9.68
6	15.13	15.13	9.81
7	15.07	15.38	9.56
8	15.19	15.19	9.94
Average	15.21	15.22	9.78

Incidentally, it was found that loss of prussic acid also occurred when a powdered sample was exposed to room temperature for some time. Drying the whole beans in the sun and at the temperature of boiling water under vacuum, removed part of the hydrocyanic acid from the beans. These results are shown in Table IV. In this table, No. I shows that the loss of HCN after exposing the powdered beans to room temperature for 3 weeks was 19.46 per cent of the original HCN content; the loss after drying the whole beans (No. 2) in the sun for 4 days was 5.65 per cent, while in No. 3 it was 13.78 per cent, and in No. 4 the loss was 77.80 per cent. A commercial possibility for the removal of HCN from these beans is indicated by the latter results.

b. The quantitative determinations.—Table V shows the results of the quantitative analysis of the beans as described on pages 168 and 169.

TABLE IV.—*Loss of HCN when beans were subjected to different treatments.*

No.	Treatment.	Variety used.	Moisture lost.	HCN content per 25 grams before treatment.		HCN content per 25 grams after treatment.		HCN in per cent of treated beans.		Loss in per cent of total HCN of fresh sample.
						Fresh sample.	Dried sample.	Fresh sample.	Dried sample.	
			per cent	*mg.*	*per cent*	*mg.*	*mg.*	*per cent*	*per cent*	
1	Powdered sample exposed to room temperature for three weeks...	College wild purplish brown..	6.69	15.21	0.0608	12.25	13.13	0.0490	0.0525	19.46
2	Whole beans dried in the sun for four days.....	College wild purplish brown..	0.44	15.21	0.0608	14.35	14.59	0.0574	0.0584	5.65
3	Whole beans dried in the sun for four days.....	Lipa wild pale brown.....	4.76	61.36	0.2454	52.92	55.57	0.2117	0.2222	13.78
4	Whole beans dried at 100° C. for one hour under vacuum.....	Lipa wild pale brown.....	4.01	61.36	0.2454	13.70	14.27	0.5480	0.0571	77.80

TABLE V.—*Prussic acid content of some Philippine beans (Phaseolus lunatus).*

No.	Variety name.	Conditions of sample.	HCN per 25-gram sample.		Remarks.[a]
			mg.	*per cent.*	
1	College wild purplish brown sibatse (F_5)	Ripe beans	15.22	0.0608	Av. of 8 determinations. Variation: +.0003%.
2	College wild black sibatse (F_3)	Ripe beans	23.52	0.0940	Av. of 8 determinations. Variation: +.0003%.
3	Lipa pale brown sibatseng gubat	Ripe beans	61.36	0.2454	Av. of 8 determinations. Variation: +.0001%.
3-a	Lipa pale brown sibatseng gubat	Beans from green pods	14.38	0.0575	Av. of 8 determinations. Variation: —.0004%.
4	Talisay black sibatseng gubat	Ripe beans	20.71	0.0828	Av. of 8 determinations. Variation: —.0003%.
5	Talisay white sibatseng gubat	Ripe beans	20.64	0.0825	Av. of 8 determinations. Variation: —.0002%.
6	Talisay purplish brown sibatseng gubat	Ripe beans	79.69	0.0787	Av. of 8 determinations. Variation: —.0001%.
7	Talisay light purple sibatseng gubat	Ripe beans	15.38	0.0615	Av. of 8 determinations. Variation: —.0001%.
8	Taal black semi-cultivated sibatse	Ripe beans	13.80	0.0552	Av. of 8 determinations. Variation: —.0001%.
9	Taal white semi-cultivated sibatse	Ripe beans	12.26	0.0490	Av. of 8 determinations. Variation: +.0002%.
10	Taal purplish gray cultivated patani	Ripe beans	7.42	0.0296	Av. of 8 determinations. Variation: +.0002%.
11	Los Baños purplish gray cultivated patani	Ripe beans	2.83	0.0112	Av. of 3 determinations. Variation: +.0001%.

[a] The variations in each eight determinations were not great. They were likely due to titration.

According to Table V, No. 3, the ripe beans from *sibatseng gubat,* the pale brown *Phaseolus lunatus,* contain 2,454 milligrams prussic acid per kilogram, or about twelve times as much as beans permitted to be sold by the French Government. According to this table, all of the varieties with the exception of No. 11, the Los Baños purplish gray cultivated patani, would be excluded from the market were the French regulations followed here.

The fatal dose of HCN to man according to Cushny is about 50 milligrams. On the supposition that the HCN in the beans would be easily liberated in the human stomach, the following will be the amount of these beans necessary to produce fatal results if eaten by man.

TABLE VI.—*Amount of each bean necessary to give the fatal dose of HCN to man.*

No.	Bean.	Fresh Beans.	Cooked beans drained from the water used in boiling. Assuming 20% of HCN is left in the beans.		Remarks.
		grams.	*grams.*	*Tablespoonfuls.*	
1	College F_5	82	410	25	
2	College F_3	53	265	15	
3	Lipa pale brown	20	100	6	
3–a	Lipa pale brown (green beans)	87	435	26	The per cent of HCN left in the beans after cooking will depend on the variety and condition of the beans.
4	Talisay black	60	300	18	
5	Talisay white	60	300	18	
6	Talisay purplish brown	64	320	19	
7	Talisay light purple	81	405	24	
8	Taal black	91	455	27	
9	Taal white	102	510	31	
10	Taal purplish gray	169	846	51	
11	Los Baños purplish gray	447	2235	134	

There is a general belief among people that the poisonous substance, the HCN, of wild varieties of *Phaseolus lunatus* can be lessened by cultivation. Table V shows that the College wild black (F_3), which had been under cultivation for three years and the same variety, wild, from Talisay contain about the same amount of HCN. The cultivated beans contained a slightly greater amount. The variation would undoubtedly be due to the different soils and climatic conditions of the two places. Sibley (14) states that the amount of HCN content of beans varies with the soil and climatic conditions. He also states that the formation of HCN in beans is an inherited character of pure single plant culture. The fact that the so-called cultivated beans have very much lower percentage of HCN than the wild ones has not been due to cultivation, but merely to selection, for people would naturally plant for food the harmless rather than the bitter and poisonous varieties.

3. EFFECT OF BOILING WITH WATER AND WITH 50 PER CENT ACETIC ACID ON THE HCN CONTENTS OF POISONOUS BEANS

a. Effect of boiling beans in water.—The writer used in these experiments the Lipa wild pale brown, the College wild black (F_3), and the Talisay wild black beans, which were found to contain the greatest amount of prussic acid. The experiments were run in triplicate. Each sample was boiled for two hours in two 400 cc. portions of water. The liquor was decanted at the end of each hour and analysed both qualitatively and quantitatively for HCN.

TABLE VII.—*Effect of boiling on the prussic acid content of beans.*

Treatment.	Variety used.	HCN content per 25 grams originally present.	HCN content per 25 grams after treatment. [a]		Amount of HCN removed in the water decanted off.				HCN removed from the beans at the end of second boiling.	
					First.		Second.			
			mg.	in % of total HCN	mg.	in % of total HCN	mg.	in % of total HCN	mg.	in % of total HCN
The whole beans were boiled for 2 hours. The water was renewed at the end of the first hour.	1. Lipa wild pale brown	61.36	1.57	2.563	2.23	3.628	1.59	2.433	58.80	99.071
	2. College wild black F_3	23.52	0.95	4.081	1.081	1.260	0.75	3.316	19.44	95.59
	3. Talisay wild black	20.71	0.85	4.130	1.060	4.876	0.68	3.187	16.58	95.80
Green beans were boiled for one hour. The water was not drained out.	4. Los Baños purplish gray (cultivated)	4.33	None	None	—	—	—	—	4.33	100.00
Variation			1.	+.001%	1.	+.001%	1.	+.001%		
			2.	+.001%	2.	+.002%	2.	+.001%		
			3.	+.001%	3.	+.001%	3.	+.002%		

[a] Average of 3 determinations in each variety.

The boiled beans were also analysed for HCN after boiling for two hours. This length of time was sufficient to thoroughly cook the Lipa wild pale brown variety but not the two black varieties. The results are given in Table V. Samples of cultivated beans from green pods originally containing 4.33 milligrams HCN per 25 grams were also boiled until they were cooked. This operation took about one hour. The liquor in this case was not decanted off. The whole mass was ground into paste by pressing the beans with the thumb and forefinger. The mixture was then analysed for HCN in the usual way. The results are given in Table VII.

This table shows that of their original contents of HCN, the Lipa wild pale brown *Phaseolus lunatus* which originally contained 0.245 per cent of HCN, lost, after boiling for two hours, 99.07 per cent; the College wild black (F_3), which originally contained 0.094 per cent of HCN, lost 95.59 per cent; and the Talisay wild black, which originally contained 0.083 per cent of HCN, lost 95.80 per cent. The green beans were freed completely from HCN by boiling one hour.

b. Effect of boiling the beans with acetic acid.—Since HCN is a much weaker acid than acetic acid, it was thought that boiling the beans with vinegar in the water would completely remove the prussic acid. The same varieties used in Table VI were employed in these experiments. The beans were boiled with 50 cc., 50 per cent acetic acid and after decanting the liquid the beans were analyzed for HCN. Qualitative tests gave negative results, showing the complete removal of HCN.

4. THE EFFECT OF FEEDING THE BOILED BEANS TO GUINEA PIGS

The boiled beans obtained in experiments described above were given to guinea pigs. The amount given to each was equivalent to 34.9 grams of the raw beans. The Lipa wild pale brown, and the College wild black (F_3), the varieties containing the largest percentage of HCN were used, both after boiling in plain water and with 50 per cent acetic acid. Table VIII shows the results of the feeding experiments.

The acidity of the beans boiled with acetic acid was partly removed by treating them with lime water and washing thoroughly with water. In the case of the beans boiled with water, the animals ate only small amounts, perhaps because of its bitter taste; of the beans boiled with acetic acid, the animals ate almost all of their portions, even though they were slightly sour. The animals fed with beans boiled in water alone became sluggish in fifteen hours and remained in that condition for four hours, while animals 3 and 4, fed on beans treated with acetic acid, showed no apparent ill effect. After 24 hours, the feed for the first two animals was renewed but they still refused to eat, though they were apparently very hungry. The feeds of the animals were then exchanged so that pigs 1 and 2 received the acid-treated beans and pigs 3 and 4 the water-boiled ones. The first two animals now ate their ration and the other two refused to eat. For lack of time the experiment was discontinued. The results show that guinea pigs easily detected the presence of even as low as 0.0063 per cent of HCN in the boiled beans, the amount of HCN found in the Lipa wild pale brown variety after boiling with water for two hours.

TABLE VIII.—*Feeding trials with guinea pigs using the boiled beans.*

Animal number.	Variety used.	Treatment.	HCN content per 25 gm. sample after boiling.	Amount eaten.	Remarks.
			mg.		
1	Lipa wild pale brown.....	Boiled in plain water for two hours.	1.57	Very little	Animals became sluggish 15 hours after the experiment was started and remained so for four hours.
2	College wild black (F_3).....		0.95	Very little	Effect similar to No. 1 although not so pronounced.
3	Lipa wild pale brown.....	Boiled in 50 per cent acetic acid for two hours.	1.57	Practically the whole ration was consumed.	No apparent ill effect.
4	College wild black (F_3).....		0.95	Practically the whole ration was consumed.	No apparent ill effect.

CONCLUSIONS

1. The hydrocyanic acid contents of a number of varieties, both cultivated and wild, of *Phaseolus lunatus* have been determined with the following results:

	Per cent HCN
Wild variety	0.060–0.240
Semi-wild variety	0.049–0.055
Cultivated variety	0.030
Green beans, wild variety	0.030
Green beans, cultivated	0.011

2. *Phaseolus mungo*, calamismis (*Psophocarpus tetragonolobus*) and cowpea (*Vigna sinensis*) do not contain hydrocyanic acid.

3. There is a gradual loss of HCN in powdered beans exposed to room temperature and in whole beans exposed to sunshine. Heating whole beans under vacuum for one hour at 100°C. removes 76.74 per cent of the HCN content. The latter method may be developed into a commercial way of removing HCN from the beans before placing them on the market.

4. About 95 per cent of the HCN content of beans is removed by boiling then with water for two hours. Even after this treatment, the beans contain enough of the poison to give it a bitter taste. Boiling with acetic acid for two hours drives out the hydrocyanic acid completely.

5. Beans boiled with acetic acid for two hours and then treated with lime water to remove the sour taste are relished by guinea pigs and produce no ill effect on them. Beans boiled in a plain water for two hours are not relished by these animals, even when the latter are hungry to the point of starvation.

RECOMMENDATIONS

The wild varieties of *Phaseolus lunatus*, as well as the cultivated ones, containing HCN, may be safely used as human food provided they are boiled thoroughly in vinegar 50 per cent strong and the liquid thrown away. To remove the sour taste, the boiled beans may be treated with lime water, and then washed thoroughly with boiled water. When not treated in this way, the beans are not safe articles of food, since small amounts of HCN would be left, and this may cause a bad effect, to greater or less degree, on the health.

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THE GAS IN THE COCONUT[1]

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The physical and chemical changes taking place in the developing coconut have been studied by a large number of workers (1) (2) (3) (4) (5), but the fact that they have attacked the subject from an agronomical or from a chemical point of view means that our knowledge of its physiology is still far from complete. In the following paper is presented some data on the origin and nature of the gas found in the nuts.

The process of fertilization of the coconut has been dealt with by Hunger (5). The changes in the ovule after fertilization follow the lines of development typical of Angiosperms. The process is described in textbooks on the subject (6). One of the generative nuclei of the pollen tube unites with the egg nucleus in the embryo sac while the other passes on and fuses with the endosperm nucleus. The egg nucleus develops a cellulose wall and by repeated division gives rise to the embryo, while the endosperm nucleus divides, forming a large number of nuclei in the protoplasm of the embryo-sac. Later these nuclei form cell walls round themselves and these cells compose the tissue of the endosperm.

The protoplasm lines the walls of the embryo-sac, and encloses a vacuole. The milk of the developed coconut represents this vacuole, and the endosperm or "meat" forms a parietal layer corresponding to its origin from the endosperm nuclei. In section the cells of the endosperm are found to be tubular and radial and, when mature, are three to four times as long as wide. When first formed they are approximately spherical. Their further growth is hampered laterally by their neighbors, and consequently they become elongated in the direction of the diameter of the fruit. The development of the endosperm cells continues for about ten months. After this time there is very little increase in number, though considerable chemical change takes place.

The development of the endosperm of course begins at fertilization, but the formation of cell walls is at first slow. For the first few months the amount formed is small and is represented by a gelatinous layer at the end remote from the embryo. When the nut is six months old the amount of endosperm becomes appreciable to the casual observer. "The meat has begun to form." By repeated division of the nuclei, followed by cell formation, the endosperm is produced as a continuous layer round the cavity.

The cavity is filled with liquid until the endosperm has attained considerable thickness and is apparently solid enough to preclude the possibility of the passage of gas through it. The epicarp and endocarp, indeed, together form an effective barrier against the entrance of gas from the outside, the weak point being at the embryo end where passage is possible. An examination of the endosperm and embryo shows that there is the possibility of the passage of air from the outside to the inside. The cylindrical cells of the endosperm have

[1] Experiment Sation contribution, No. 106.

relatively large air spaces between them in spite of their apparent close packing when examined with the naked eye.

Any doubt as to the origin of the gas ceases when a number of analyses are made. In the experiments performed a number of nuts of various ages were chosen, and the gas analysed. According to the age of the fruits the composition varied. The amount naturally varies. In young nuts there is none; after the endosperm is well formed, it begins to appear, and when the nut is old about 25 cc. may be found. The first analyses were done on old nuts, and the gas proved to be practically pure nitrogen. This suggested that the nitrogen was residual, and so some young nuts were examined. In nuts containing only 2 or 3 cc. of gas, the composition was found to be very comparable with that of air, the oxygen content being somewhat lower, as is to be expected.

A considerable amount of gas from different young nuts containing 2 to 3 cc. of gas was analysed with the following result:

Nitrogen	81.3%
Oxygen	18.7%
Carbon dioxide	trace

In old nuts where the amount of gas averaged 23 cc. per nut, the following was the typical analysis:

Nitrogen	99.8%[2]
Oxygen	.2%
Carbon dioxide	trace

These results show that the gas in the young coconut is air which has entered by way of the one functional germinal pore. (There are three germinal pores, and two are functionless.) As the fruit increase in age more air is admitted, but the oxygen is used in the vital processes of the plant, and the physiologically inactive nitrogen is left.

It now becomes necessary to enquire into the disposal of the oxygen. Is it used in the normal respiration of the cells or is it used in the transformation of the food materials of the endosperm?

The cells of the endosperm contain an extremely large amount of oil, but this is not the case in the younger nuts (2). The percentage of oil increases suddenly during the closing stages of ripening and thus during the germination period decreases and sucrose and invert sugar increase markedly at the same time. The utilization of fats by germinating seeds means the use of tremendous quantities of oxygen. Detmer (7) considered starch to arise from free oleic acid (which is derived from fats) according to the equation

$$C_{18}H_{34}O_2 + 27\ O = 2C_6H_{10}O_5 + 6CO_2 + 7H_2O.$$

This would easily account for the utilization of the small amount of oxygen represented by the volume of nitrogen in a mature fruit of coconut—about 5 cc. at the most. This oxygen is not necessary to the endosperm cells for their normal respiration, as the air is not present till late in the development of the fruit and until that time they have been able to obtain the necessary oxygen from other sources.

The embryo of the coconut is a little different from the type in most oily seeds in that its development is continuous, so that the term germination is rather

[2] No distinction is made here between nitrogen and the other inert gases of the atmosphere (argon, helium, krypton, etc.).

indefinite. What is usually regarded as germination may be retarded or accelerated by varying the water supply, but strictly speaking there is no long period of resting such as takes place between the maturing and germination of a normal seed. The presence of lipase in the embryo and in the milk and endosperm in smaller quantities has been demonstrated by Roxas (4). The continuous splitting of fats by the enzyme and the utilization of the products requires large amounts of oxygen and part of this is provided by the air admitted to the coconut on evaporation of part of the water of the fruit.

It is worthy of note that the slight pressure present in the coconut is not due to the included gas, but to the liquid present in the turgid fruit. This is apparent when a young nut without any gas is examined. The milk will often spurt out when the endosperm is punctured. The same thing may be noticed in other palms, e. g., *Arenga pinnata*, when the turgidity is maintained. If the endosperm and testa be dissected intact out of the outer layers of epicarp and endocarp this turgidity may be decreased by exposure to the air and restored by immersion in water. The fact that the gas is residual would also indicate that it is not responsible for the pressure.

SUMMARY

1. Gas appears in the coconut after the endosperm is well developed.
2. The composition of the gas in the early stages of development is almost that of air, but the oxygen content is rather lower than that of air. As the age of the nut increases the quantity of gas increases, but with progressive decrease in percentage of oxygen.
3. The oxygen is used in the utilization of fat by the embryo, and nitrogen and the inert gases are left forming almost the entire volume of the gas in the old nut.
4. The pressure present in the coconut in due to turgidity, not to the presence of gas.

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A PRELIMINARY STUDY ON THE REPRODUCTION AND FEEDING HABITS OF DERMOGENYS VIVIPARUS PETERS[1]

By Feliciano R. Reveche

INTRODUCTION

In the summer of 1921, Mr. D. Villadolid, of the Department of Entomology, College of Agriculture, while making a preliminary study on the feeding habits of the fish fauna of Molawin creek, had occasion to collect a few living specimens of *Dermogenys viviparus* Peters[2] for some biological experimentation. In connection with this study, he found out that this species of fish is a voracious feeder on mosquito larvae.

In June, 1922, Mr. W. D. Tiedeman, of the International Health Board of the Rockefeller Foundation, who is working in cooperation with the Philippine Health Service, arrived at Los Baños and made his headquarters at the College of Agriculture, to study malaria condition in Laguna Province and the possibilities of economic control. He became interested in fish as a possible means of checking the rapid multiplication of mosquitoes. This fish was then mentioned to him by Prof. H. E. Woodworth, of the Department of Entomology, as possible material to work with.

The present is a report on the feeding habits, method of reproduction, local distribution and life history of *Dermogenys viviparus* Peters. This work was begun in the latter part of July, 1922, and ended at the close of November of the same year. The work was done in the College of Agriculture, University of the Philippines.

GENERAL INVESTIGATION

1. DESCRIPTION OF DERMOGENYS VIVIPARUS PETERS

Among the Tagalog people the name "Patlay" and "Kansusuit" are synonymous terms, and these are applied to either of the two fish, *Dermogenys viviparus* Peters or *Zenarchopterus philippinus* Peters. *Dermogenys viviparus* Peters, the subject of this paper, is smaller than the other. For the purpose of uniformity, it would be better to adopt the term "Patlay" to *Zenarchopterus philippinus* Peters and the term "Kansusuit" to *Dermogenys viviparus* Peters, for the simple reason that the people more commonly use "Kansusuit" for *D. viviparus*. The term "Patlay" seems to be commonly applied to a fish having long, slender body and capable of swimming very fast; on the other hand, the term "Kansusuit" seems to be applied to small fish with a body not well adapted to swim rapidly. The former is more characteristic of *Zenarchopterus philippinus* Peters and the latter to *Dermogenys viviparus* Peters.

Peters (1) described this fish as follows: "Tail fin convex; dorsal fin shorter than annal fin; its first ray inserted behind first annal ray; annal fin inserted

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[1] Experiment Station Contribution No. 107.

[2] Identified by Dr. A. W. C. T. Herre, of the Bureau of Science. Fowler and Bean, of the Academy of Natural Science of Philadelphia, identified some Philippine specimens which they found labeled *Dermogenys viviparus* Peters as *Hyporhamphus neglectus*. It cannot be determined where these specimens originated. To check this, however, a bottle of specimens was sent by Mr. W. D. Tiedeman, Field Director of the Rockefeller Foundation in the Philippines, under whom this work was undertaken.

after 9/16 of the total length; head semi-flattened; length of head equals 5/16 of the total length; apex of beak yellowish speckled with black, three lines extend from the neck toward dorsal fin, membrane between first and second annal ray, second and third dorsal parts basally spotted behind the operculum with black. Number of scales along longitudinal line 45, transverse 12 to 13, dorsal 10 to 11, annal 14 to 15. Total length 95 mm."

Peters further states, "this species is in its whole body structure very similar to the preceding but considerably larger and one could perhaps consider both as one, but due to the rounded and not two lobed tail fin, as well as to the short dorsal fin, one distinguishes an easily recognizable subgenus of the remaining *Hemirhamphus* for which reason this name *Dermatogenys* (*Dermogenys*) suggested by von Kuhl and van Hasselt was adhered to.

"Dr. Jagor brought this last species from the island of Samar from the river Basey, as is shown in the foregoing specimen 'with living young and developed eggs' ".

Distinct external characteristics of both sexes.—

The female, as a rule, is much larger than the male. The average measurement which is taken from 175 specimens of adult females is 73.5 millimeters in length, and the average measurement of the male, taken from 95 adult specimens, is 52 millimeters in length. The measurement is taken from the tip of the beak to the tip of the tail. All these specimens were caught in the Molawin creek, Los Baños, Laguna.

The caudal fin of the male is beautifully marked with black and pale orange. This marking at the tail is sometimes present in the female, but is not as clear as in the male. The soft rays of the dorsal fin of the male are colored black, and this marking is absent in the female. The ventral fin of the male is also colored pale orange and sometimes little black marks are mixed with it. In the case of the female, the ventral fin is whitish brown, the marks predominating at the soft rays on attaining old age. On the ventral side of the beak of both sexes is a thin fleshy protrusion which runs from the base of the beak to its tip. This protrusion is distinct reddish orange in male, and orange in the female. In the case of the female, there is a protuberance just anterior to the anus which is orange in color. This is absent in the male.

2. THE ALIMENTARY CANAL AND CONTENTS

a. *Method of investigation.*—

The stomach contents of the fish were determined by dissecting the stomach and making water mounts of its contents. Examination was made under a dissecting microscope (×24) or under a binocular microscope (×40).

b. *Digestive system.*—

The alimentary canal of the female fish is a simple tubular organ. It is almost pale white in color, and is situated ventrally to the two sacs of the ovary. It may be resolved into three parts. The most anterior part which is a short, small tube is supposed to be the rudimentary oesophagus, and next to it is a dilated and enlarged portion which may be termed the stomach which covers one-third of the length. The posterior part which makes about two-thirds of the length is termed the intestine. The length of the whole digestive canal is approximately 34 millimeters. The width varies because the most anterior

portion is a small, short tube and next to it is a dilated part which is the stomach and is approximately 4 millimeters in width. The most posterior part which is the intestine is about 2 millimeters in width. On each ventro lateral side of the alimentary canal are two blood vessels running parallel and terminating at the posterior portion, about two-thirds of the length. This description of the alimentary canal is taken from one specimen, 92 millimeters in length and 12.5 millimeters in depth.

c. *Stomach contents.*—

Extensive dissection of the alimentary canal of the fish was done with subsequent examination of the stomach contents. Among those things that were conspicuous in the stomach were mostly portions of body parts of insects and arachnids, such as the wings of insects, legs of spiders, heads and legs of ants, legs and abdomens of small locusts, and exuviae of some kinds of immature insects.

3. OBSERVATION OF FEEDING HABITS

Observations of the feeding habits of this fish were made in Molawin creek and in confinement. The fish is provided with a long beak, the lower lip being very much longer than the upper. The fish, therefore, must necessarily be a surface feeder. It could hardly get food at the bottom of the water. If the food happened to be at the edge of a stone or anything that will hinder its progress, the beak is used. Large food is broken into pieces by the mouth before it is swallowed. Oftentimes the young fry are in schools of from twenty to thirty individuals with a few large ones. They are usually found in a slow current of water or near the water edges in the creek or river. They are found abundantly in quiet, shady places of the creek. This is also true with the adult fish, but the latter is often found in more or less rapid currents in which they oftentimes stay and swim. Most of the time they are found on the surface of the water, arranged one after another against the current. They seem to be waiting for their prey to come along with the current of the water. They are very sensitive to noise or disturbances in the water. They react to it positively thinking it possible to be a chance for prey, but are easily frightened at the sight of their enemies. Fighting was observed between individuals in a group over the possessions of a piece of food. If they happened to be of about equal size, they fought hard and strong. They used their beaks as a means of offense and defense.

At night they behave in a very different manner. Most of them are found along the water edges especially in small indentations and stagnant places, swimming around and actively looking for food. They are very active at night, swimming from place to place. This fish is positively phototropic. The writer had occasion to catch a large number of these fish during the night, by attracting them with a lantern into the net.

In pools where this fish was artificially reared, food was given once a day. This food consisted mainly of larvae of both anopheles and culex mosquitoes. Later dried shrimps and white ants or termites were given. The dried shrimps were cut into small pieces before they were given and as such they could be easily swallowed by the fish. Of all this food, the writer found that the fish prefered the anopheline larvae. This might possibly have been due to the fact

that the anopheline larva places itself parallel to the surface of the water. It could be, therefore, readily seen by the fish which feeds on things floating on the water. It may be that in nature it prefers water insects as examination of the stomach contents would seem to indicate.

The following table shows how readily anopheles larvae are eaten by this fish when in confinement. It remains to be seen how this would be modified under natural conditions.

TABLE I.—*Showing the efficiency of Dermogenys viviparus Peters in eating mosquito larvae in an artificial container.*

Date.	Fish number.	Number of anopheline larvae given.	Number of larvae eaten after					Total 5 hrs. & 38 min.
			8 min.	30 min.	1 hr.	2 hrs.	3 hrs.	
11–27–22.....	A_1	82	36	+ 7	+16	+10	+ 9	78
11–27–22.....	A_2	59	39	+ 1	+10	+ 3	+ 5	58
11–27–22.....	A_3	53	9	+ 6	+12	+16	+ 9	52
11–27–22.....	A_4	54	2	+ 5	+ 9	+15	+10	41
11–27–22.....	A_5	57	13	+24	+ 3	+ 9	+ 6	55

4. METHOD OF REPRODUCTION

Examination of reproductive organs.—

In the differentiation of the males from the females, the external anatomy was first studied, followed by the dissection for the internal organs. In this connection particular attention was paid to the number of fetuses and developed embryos inside the ovary sacs.

The ovary of this fish is V-shaped in form, and is composed of two sacs. Oftentimes, one of these sacs is shorter than the other. Generally, the color of the ovary is silvery with black markings at the side of each sac. The ovary is located dorsally to the alimentary canal, the latter running straight between the two sacs. It extends from the cloaca to the level of the liver.

The arrangement of the fetuses inside the ovary sacs can be seen from outside, due to the fact that the sac membrane is transparent. The young fetuses in the sacs overlap each other. The position of the fetuses in the sacs is not the same. Oftentimes the heads of the fetuses point toward the cloaca and at other times they point toward the blind portion of the ovary sacs.

The most common number of fetuses is five in each sac. This number increases with the size and age of the fish. In the ovaries there are always found developed embryos and eggs. Measurements of the young fetuses, which supposedly are about to be delivered, were taken. The average length is 18 millimeters.

TABLE II.[1]—*Showing the relative length of the ovary sacs in relation to the total length of the fish with the number of fetuses and embryos found in the ovary sacs.*

Specimen number.	Length of fish.	Ovary sac number	Length of ovary sacs.	Number of fetuses and embryos in the ovary sacs.	
	Millimeter		Millimeter	Fetuses	Embryos
1	63	1	18	4	7
		2	18	5	9
2	120	1	35	10	7
		2	35	11	4
3	50	1	10	—	7
		2	10	2	4
4	85	1	25	4	3
		2	20	5	2
5	63	1	20	3	6
		2	12	7	4
6	60	1	13	5	5
		2	13	4	6
7	65	1	15	—	3
		2	15	—	4
8	98	1	25	5	4
		2	25	5	6
9	60	1	18	3	2
		2	18	5	3
10	64	1	16	5	9
		2	16	4	10
11	100	1	30	11	2
		2	30	5	7
12	75	1	20	4	7
		2	20	—	6

[1] For lack of space only twelve specimens were noted in this table.

It is shown in the above table that the length of the ovary sacs vary according to the length of the females. Generally, the larger or older females have more young fetuses and embryos in the ovary sacs while the smaller or the younger the females the less the number of fetuses. The fact that the young fetuses are not found in some cases in the ovary sacs of the females may indicate that this fish has a resting period.

5. LIFE HISTORY

Couples of *Dermogenys viviparus* Peters were confined in separate compartments, fed with mosquito larvae or termites, and kept under close observations. As soon as each female produced young, the latter were transferred to Lot B_1, B_2, B_3, B_4, B_5, B_6, B_7, as shown in the succeeding table. Other couples selected from this stock were transferred and confined in another compartment shown as C_1, C_2, C_3, C_4, C_5, C_6, C_7, C_8, C_9, in the same table.

TABLE III.—*Showing intervals between parturition and life history of Dermogenys viriparus* Peters *under confinement.*

Couple confined in lot Number.	Date of confinement.	Successive dates of parturition.	Interval between parturition.	Number of young born.	Number of lot to which young were transferred. First generation.	Number of females.	Number of males.	Number of couples separated from first generation placed in lot No.	Date of paturition. Second generation.	Number of young born.	Number of females.	Number of males.	Age at which first generation gave young.
			days										*days*
A*1*	8/9/22*	8/10/22		4		3	1	C_1	11/ 3/22	3	2	1	85
		8/11/22		1	B_1	—	1	C_2	11/ 1/22	2	2	—	83
		8/17/22	6	5	B_2	3	2	C_3	11/ 6/22	2	2	—	81
								C_4	11/11/22	2	1	1	86
		8/25/22	8	5	B_3	4	1	C_5	11/16/22	3	2	1	83
		9/ 2/22	8	5	B_4	3	2	C_6					
		9/12/22	10	5	B_5	3	2	C_7					
		10/ 4/22	22	10	B_6	7	3	C_8					
		10/15/22	11	7	B_7	4	3	C_9					
		* Lost October 19, 1922.											
A*2*	8/10/22*	8/15/22		5	Lot III	3	2						
		8/24/22	9	4	Lot III	2	2						
		9/ 2/22	8	5	Lot III	3	2						
		* Lost September 20, 1922.											
A*3*	9/16/22	10/15/22		5	Lot III	4	1						
		11/ 1/22	17	8	Lot III	6	2						
		11/15/22	14	6	Lot III	4	2						
									Total				83+ days.

It is worthy of note that a single female gave birth to 5 sets of 5 young each at intervals averaging about 8 days and that these young gave birth to their first group of 2 or 3 young at the average age of only 83+ days.

a. *Notes on the stages in the development of the young embryo.*[1]

1. In the first stage of development, the young embryo is enveloped by a thin membrane (Called the chorion, in mammals). The eyes are already developed. The tubular heart is already functioning. On the dorsal part of the embryo running from the most posterior part of the head are black dots which terminate at the anterior part of the dorsal fin. This stage is characterized by the presence of a large amount of yolk.

2. In the second stage, the same characteristic features are found as in the first stage, but differ only in that in the second stage the embryo proper is larger, while the yolk is much diminished in bulk and quantity.

3. The third stage is practically the same as the second stage, but the yolk is distinctly reduced in size and quantity, and the embryo is very much larger. There are black dots appearing very conspicuously in that part of the body mentioned above. The eyes are larger.

4. In the fourth stage, the membrane or chorion which envelopes the embryo seems to bulge out but the young embryo is still coiled in the ovary sacs of the mother. The yolk is greatly diminished in quantity by this time.

5. In the fifth stage, the young fetus appears to be complete in its organs of locomotion. The black dots appearing more prominently. On each side of the young fetus there is a lateral line which begins from the sides of the pectoral fins and terminates at the caudal fin. At this stage of development, small protrusions are visible on the upper beak just anterior to the eyes one on each side.

An experiment was performed to find out whether the young fetuses would live when artificially taken out from the ovary sacs of the mother. The result was that they only lived for two or three days, and in most cases died after three days. Food was given but they would not eat.[1]

b. *Young.*—

The young are born alive. They come out one by one through the cloaca. When outside of the mother's body, they immediately swim to the surface of the water to get air. They look sluggish and inactive, but they can hardly be caught with the hand unaided. The average length of the newly born young is nineteen to twenty millimeters. At this stage, the beak is a little projection at the lower lip. The orange and black markings are absent on both sexes and their distinct color is whitish gray. An attempt made to measure the growth of some of these young failed because they were lost after three days. However, they grew one or one and one-half millimeters in length a day.

c. *Growth.*—

As the young fish grows, its activity increases. The young easily penetrate the pools and water edges seeking food. The female fish attains the mature stage when it is about fifty to sixty millimeters in length, and the male attains maturity at about fifty-five millimeters. At this stage of development, they

[1] NOTES:—It must be noted that beginning from the first stage, the young embryo appears to be transparent to the unaided eyes, but, however, the most discernible organs are the organs of sight and functioning heart.

begin to mate. The markings at this stage become distinct on both sexes so that one can easily tell the males from the females.

The female starts giving young at the age of 81 to 85 days. She gives two or three young at the first time. As the female ages, the number of young increases. This generalization is based upon the observation obtained from females reared in confinement. Commonly, an old female will give five young at each parturition, and the maximum number one has been noted to produce is ten. The record of one female (female A_1) shows that from the time she was placed in confinement up to the time she was accidentally killed, a period of 75 days, she was able to produce 42 young. So far this work tends to show that the fish is able to live under artificial conditions and can reproduce a number of young if care is given.

6. HABITAT

a. *Natural.*—

The natural habitat of this fish is the ditch, creek, river or other small stream. In Balanac river near Magdalena, Laguna, this fish was observed and was found to inhabit places of slow current or stagnated places in the river.

b. *Ability to live and reproduce under artificial conditions.*—

Dermogenys viviparus Peters lives and reproduces fairly well in pools which have free circulation of water, and has been found to thrive just as well in stagnant water. The size of the pool where this fish was reared is about four by five meters. It is divided into several lots. In lot 1, enclosed by a wire screen, twenty females and twelve males were introduced in August, 1922, and in November, 1922, the number of the fish in this lot altogether was 332. Most of the females that were introduced in this lot were 73 millimeters long and when they were counted again and examined, some of them had grown to 130 millimeters in length. The males did not exceed 67 millimeters in length. A single female fish under these conditions of confinement produced 15 offspring in the course of three months which, if there were no period of sexual inactivity, would mean 60 for the year. Bearing in mind that the rate of bearing offspring increases with age, this number will be considerably increased.

7. DISEASE

One diseased condition of *Dermogenys viviparus* Peters was encountered in the pools. The attacking organism (a fungus) belongs to the genus ACHLYA[1] which is a free living organism in the water. It grows anteriorly near the eyes of the fish at the beginning and finally affects the eyes. The fish becomes blind and dies afterward. It appears as a white filamentous growth at the head of the fish and is easily recognized. However, it is rarely found attacking this fish.

8. DISTRIBUTION IN LAGUNA PROVINCE

The fish is more or less evenly distributed through the province of Laguna. The fish may be found in the upper courses of most rivers and small streams in the province. The writer found it in abundance in Molawin creek of Los Baños, in ditches in Masiit in Calauan, in ditches in the town of Magdalena, and in ditches and creeks in San Juan, Loñgos. This fish does not seem to frequent the lower courses of the streams. In all the places visited by the writer the fish

[1] Statement from Prof. F. P. McWhorter, of the Department of Plant Pathology, College of Agriculture.

was not observed in places near the mouth of streams. In Molawin creek this fish is very scarce within about a kilometer of its mouth, but is plentiful towards the source. In Laguna de Bay and small lakes of San Pablo such as Bunot, Tikiw, Kalibato, and Sampaloc, the fish is not found.

Association with other fish.—

In the creeks, this fish is seen associated with another very small fish which belongs to the genus Gobio. The latter fish stays mostly at the bottom of the water, and wherever *Dermogenys viviparus* Peters is present the former seems to be present too.

In a pool where this fish was confined, *dalag* (*Ophiocephalus stratus*) was introduced, to find out whether the *Dermogenys* would be eaten by it. Some of the *Dermogenys* were found wounded, but none were eaten.

This fish lives fairly well with top minows (*Gambusia affinis*) in pools. In a one-half barrel filled with water where both were confined in the insectary of the Department of Entomology, they have not attacked each other.

SUMMARY AND CONCLUSION

Dermogenys viviparus Peters is locally found in the province of Laguna in more or less shady places of old streams, ditches, creeks, and rivers. The fish is a highly beneficial fish because of its predacious habits on mosquito larvae. It is a surface feeder and feeds voraciously on anopheline larvae. A small "Kansusuit" (*Dermogenys viviparus* Peters) has eaten 78 anopheline larvae in 5 hours and 38 minutes.

The development of the young embryo may be divided into five stages. The young are born alive. The small fish is generally more active than the large ones.

The female *Dermogenys* matures at the age of 81 to 85 days. She produces two or three young the first time, and as she grows older more young are given out at each parturition. The older female usually gives five young every eight days. This may vary at different seasons of the year and there may be a period or periods of sexual inactivity each year.

The fish lives and reproduces fairly well under artificial conditions. White ants or termites are the best food if it is is reared artificially.

Dermogenys viviparus Peters has some possibilities as a so-called "mosquito-fish". It is a surface feeder by nature and, in confinement, will eat anopheles mosquito larvae readily. It has been known to maintain itself in places where "dalag" and other voracious fish are present. In spite of all this, it has not been demonstrated as yet to be of economic importance in mosquito control although it may be under some peculiar conditions. The fact that the fish is so widely distributed and yet is not found in any one place in sufficient numbers to control breeding, shows that there must be many natural enemies to be overcome. It is true that the removal of grass and weeds from the edges of streams may help by making food more easily available. However, in a section of Molawin creek which is rocky and contains no weeds, we found anopheles breeding in spite of the presence of the fish.

Further work is necessary to demonstrate the practical possibilities of the use of this fish in mosquito control.

ACKNOWLEDGMENT

The author is greatly indebted to Mr. W. D. Tiedeman for his valuable help in the preparation of this paper, also to Dr. A. W. C. T. Herre of the Bureau of Science and Dean C. F. Baker of the College of Agriculture. The illustrations were drawn by Mr. Aniano Estores.

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ILLUSTRATIONS

Plate I

A. Stages in the development of the young embryo.
   1. First stage.....3 mm.....×-8
   2. Second stage.....3.5 mm.....×-8
   3. Third stage.....4 mm.....×-8
   4. Fourth stage.....4.2 mm.....×-8
   5. Fifth stage.....18 mm.....×-3

B. Dorsal view of the head of a newly born *Dermogenys viviparus* Peters..... ×-15

C. Lateral view of a newly born *Dermogenys viviparus* Peters..... ×-3

D. Ovary sacs showing the arrangement of the young fish and matured eggs inside..... ×-4

E. Ovary sacs showing the young fish inside, nearly ready to be delivered..... ×-4

F. Ventral view of the entire alimentary canal and its relation to the ovary sacs of the female *Dermogenys viviparus* Peters.... ×-2

Plate II.

1. Lateral view of the male.
2. Lateral view of the female.

Plate III.

D. viviparus Peters, showing the arrangement of scales and fins.

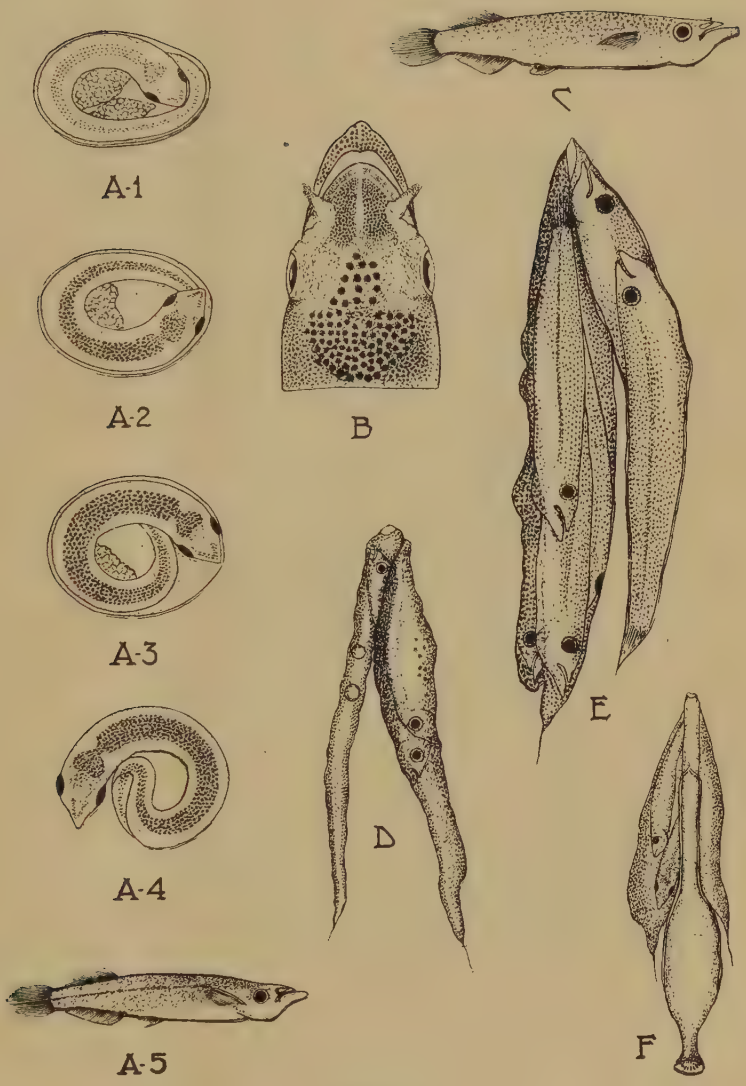

PLATE I

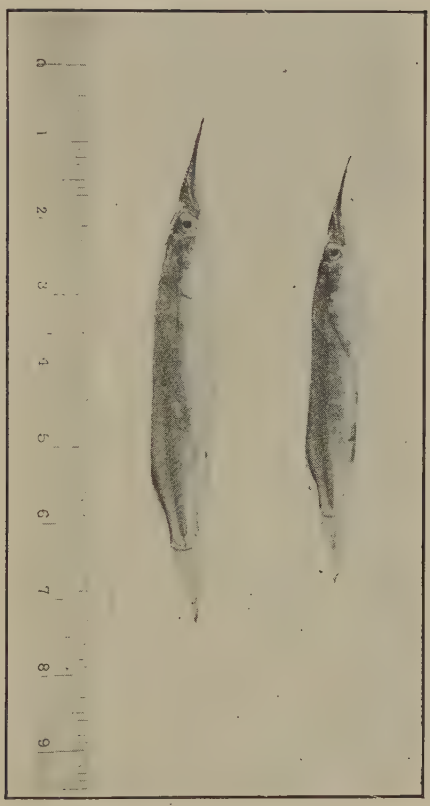

PLATE II

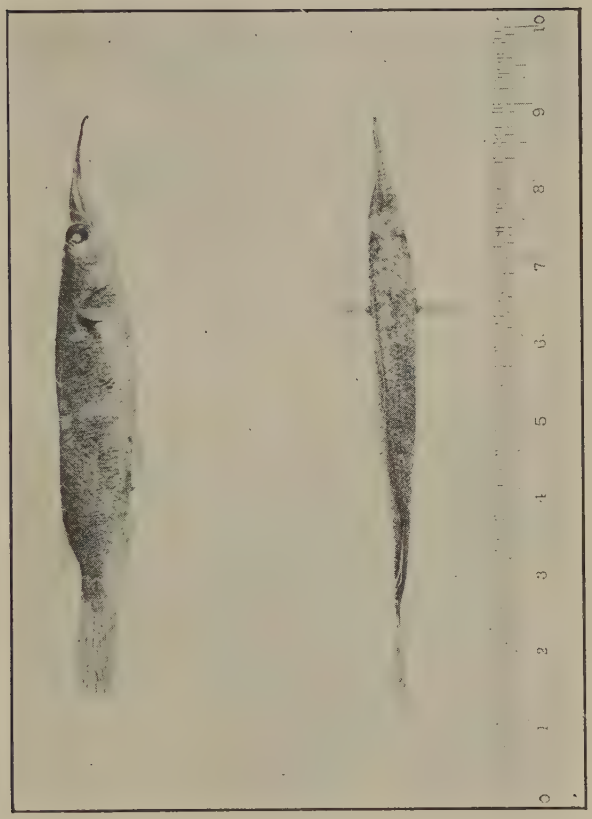

PLATE III

ON THE GERMINATION OF COCONUTS

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Although Copeland (1) and Bacomo (2) have both expressed the belief that coconuts should be used for seed only when fully ripe, yet it appears that no actual comparative tests on this matter have ever been carried out in the Philippines.

In the province of Laguna the writer has talked with several coconut planters and has seen their seed beds of coconuts in the back of their yards and has found that they use nuts the husk of which is still green, and in which the milk can be shaken. These planters argue that such nuts are better material for germination than the dry-husk nuts. They claim that they are fast growers.

In addition to the stage of ripeness of the nuts there is another point that should be considered in connection with germination of the coconuts in a seed bed, which is the right position of the nut.

Copeland in his book "The Coconut" (1) states that the seeds should be placed on the side. It may be that Copeland was using results of experiments in other countries (5), (4), (5). It appears that Philippine literature based on actual comparative tests on this subject is wanting. It was, therefore, the main object of this little class experiment (carried out at this College by a few students who took up the course on Oil Plants in the summer of 1920) (*a*) to determine experimentally whether the "green-husk" or "dry-husk" nut is better material for germination, consequently for seed; and (*b*) to determine the best position of the nut and what treatment to give it to obtain excellent germination in the seed bed. It might be said also that another object of this test was to determine the influence of watering upon the rate and percentage of germination. This study was carried out during the months when rainfall was supposed to come seldom, but the opposite was the condition in this year. The results, therefore, on germination of the nuts as influenced by artificial watering not being reliable because of the rainfall, they will not be discussed in this paper.

Summarizing the objects of the brief but careful study here reported on the germination of the coconut in the seed bed, we have—

1. To determine whether the nuts with dry husks (dead ripe) or those with green husks (the water in the shell shakes) are suitable seed nuts.

2. Which position, (top up, side down or top down) of the nuts is best in germination.

3. What treatment should be given the nut that would be favorable to rapid germination.

I. METHODS OF GERMINATION IN GENERAL

It will not be amiss to give a brief description of the different methods in vogue in the germination of coconuts, before presenting the results obtained from the study presented in this paper.

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[1] Experiment Station Contribution No. 108

The methods practiced in the Philippines and elsewhere may be classified as belonging to two or three main categories. The first we may term the Hanging Method; the second, the Seed Bed Method; and the third, the Direct to Field Method.

One way of germinating seeds of coconut by the Hanging Method is to tie the nuts in pairs by strips of their husks and to hang them over poles held in horizontal position by posts. Another way is to tie the nuts around a vertical pole, one above the other; forming a sort of cylinder with the pole at the center. The Hanging Method is employed quite commonly by the planters around the foot of Mount Banahao where the humidity of the air is high. This method should never be used when any one or more of the following conditions exist:

1. When the moisture content of the air is low during the period of germination.

2. When labor or water is not available to water the seeds when rain fails to supply the necessary moisture for the germinating nuts.

3. When the prospective plantation is ready or will soon be ready for planting.

The advantages of using the Hanging Method are:

1. It is economical. No land, no fencing required; and very little labor.

2. The nuts are safe from the attacks of anay (termites); also from wild boars, goats, and other animals.

3. Germination may be made to conform to the right time for transplanting, for with this method the germination of the nuts is within control. It can be hastened by watering and can be retarded by limiting the amount of water poured on the seeds.

4. The growth of the shoot is normal while that of the roots is very slow. The roots are not injured before transplanting as is likely to occur in digging the seedling out of the ground. Thus no time is lost after transplanting by retarded growth because of injured roots.

Good as the Hanging Method appears to be it is not very extensively employed. The method commonly used on commercial coconut plantation is the Seed Bed Method.

The Seed Bed Method as its name implies involves the preparation of a piece of land for germination. To be well suited for a germination bed, this land should have certain specific qualities. It must be free from anay (termites) and from any other minute organisms that may attack the nuts or the seedlings in the ground. The seed bed must be well drained and near a source of an ample supply of water in time of drought for sprinkling or whenever watering is needed. Moreover, in order to save labor in transportation the proposed seed bed should be located near the main field where the seedlings are to be transplanted.

In planting the nuts in the seed bed, consideration should be given, (1) the arrangement of the nuts in the bed, (2) the distance between nuts and (3) the depth the nuts should be buried in the ground.

As to arrangement, although the nuts may be germinated without any definite arrangement in the seed bed, yet it is very convenient to place the nuts laid side by side in straight rows, forming square plots of about 3 meters by 3 meters or rectangular plots or beds 3 by 2 meters each. A footpath between plots of about a meter in width should be made to use in making inspection, watering, and in selecting vigorous seedlings for transplanting. This scheme is advisable if the seedlings are expected to be transplanted early.

Other schemes of preparing the bed may be followed. The nuts may be arranged also in straight rows, but, in this case, the rows should be set rather far apart. The distance between the rows of nuts and the distance between the nuts in a row should be determined by the age at which the seedlings are transplanted. In no case should the distance between the rows exceed one meter, for it is not usually desirable to allow the seedlings to grow with the shoot longer than about 30 centimeters. The seeds should be set in the row rather close together and the distance between the rows should be about 25 centimeters or enough to allow a person to pass. The space between the rows may serve also as a secondary drainage canal.

The depth of setting the seeds in the bed is governed by the length of time the seedlings are to be left there before transplanting, and to a less degree is governed also by the physical character of the soil and the climate of the locality. In loose soil and if the seedlings are to be allowed to grow tall, the nuts should be entirely or almost buried in the ground. On the other hand, if seedlings are to be transplanted at less than about 30 centimeters in height, the nuts may be two-thirds, one-half, or one-third buried in the ground. To obtain a rapid germination, however, the nuts should be entirely buried. This method is also advisable if the drying influence of the air is great around the seed bed. The nuts then will be in the ground and the shells prevented from cracking, a condition which is oftentimes the cause of the death of seedlings or the failure of the nuts to germinate. This result was observed in the present study where the husks of the nuts were either partly or entirely removed. The shells of most of the nuts that received this treatment cracked. The seeds failed to germinate or, if they did sprout, the seedlings did not continue to grow. Micro-organisms, which according to our casual observation were either bacteria or fungi or both kinds, attacked the cotyledon as well as the endosperm. This caused decay.

The Jaffna Method practiced in the northern part of Ceylon is essentially the same as the seed bed method practiced in the Philippines, except that in the Jaffna method the seedlings are transplanted to a nursery bed for further growth before planting in the permanent plantation. It would appear that unless labor is cheap this method is not practicable and the transplanting of big seedlings is undesirable.

The Direct-to-Field Method involves the preparation of no seed bed or nursery bed. The nuts before they germinate are set directly in holes in the permanent field. This method saves labor but does not insure either rapid or uniform

germination of the nuts. In fact, the germination under this condition is rather slow and a good many nuts usually fail to germinate. The nuts are subject to attacks of anay and also by wild hogs. Should this method be practised it is advisable that a small nursery bed be established and the seedlings from this be used in filling out vacant hills in the plantation.

In the present study no attempt was made to try all or the different methods of germination of coconut seeds herein described. The Seed Bed Method only was employed.

II. MATERIALS AND METHODS

A nursery bed was prepared for this study out of one of the plots on the College Farm. On April 14, 1920, seeds of Laguna type of coconuts were laid on plot, about half buried. One or two of the husked nuts, being small, were entirely covered with the soil by the rain that fell while the experiments were in progress. Consequently as these nuts were protected their shells did not crack with the result that germination was rapid.

The nuts used were of the same variety but in two distinct stages of development. One set of sixty had green husks and another set of sixty had dry husks. With this limited number of nuts, it was possible to include only 12 dry-husk nuts and 12 green-husk nuts in each of the five kinds of treatment. The nuts were treated as follows:

1. Nuts with top end up.
2. Nuts with top end down.
3. Nuts lying on the side.
4. Nuts with one-fourth of the husk removed and lying on the side.
5. Nuts with entire husk taken off.

During the first days this study was in progress some of the nuts were watered every day; with the object of ascertaining the influence of watering on the rate and percentage of germination, but in the latter part of the time rain fell making it impossible to continue this phase of the investigation. With the climatic conditions existing on the College Farm it is almost impossible to carry out an experiment of this kind even during summer days unless the nuts are placed along the sides of the building, or in a glass house, or some sort of shelter can be spread over the nursery bed whenever the rain is falling.

Before presenting the results of this study, it should be emphasized that the nuts, the growth data of which are presented in each horizontal column of figures in Table I, were apparently uniform in size and shape,—some came from the same bunch or cluster and the others were expressly selected for uniformity in size and shape and degree of ripeness. The difference in results obtained was apparently due to the difference in treatment given the nuts and not to any difference that was discernible in the nuts.

III. DISCUSSION OF RESULTS

On September 10, 1920, about five months from the time the seeds were placed in the seed bed a final observation on the apparent condition of the seed-

lings and of the nuts that failed to germinate was made. Likewise measurement of the height of the tallest leaf of each seedling was made. The data obtained are presented in Tables I, II, III.

Table I shows the height of the tallest leaf of each seedling; and the nuts that appeared normal at the end of the experiments but had not yet germinated. These are presented by *O*. The nuts that died and those that were lost are indicated in the table by *d* and *l*, respectively. Nuts that were husked, especially those that cracked, were the ones lost. Since the majority of the husked nuts lost were cracked, they did not germinate well or failed to sprout completely. The loss was not serious and does not lessen the value of the results obtained.

The data in Table II are the arbitrary values of the data in Table I. In Table II the height of the shoot between 90 centimeters and one meter is considered *1;* between 80 and 90 centimeters, *2;* 70-80, *3;* 60-70, *4;* 50-60, *5;* and *0* for heights below 50 centimeters. The nuts that were lost and those that died are indicated in the table with *l* and *d*, respectively. A summary of the values in Table II is shown in Table III.

TABLE I.—*Length of the tallest leaf of each seedling.*

Nut No.	Husked nuts.		One-fourth husked nuts		Unhusked nuts.					
					Top down.		Side down.		Top Up.	
	Dry.	Green.	Dry.	Green.	Dry.	Green.	Dry.	Green.	Dry.	Green.
	cm.	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*
1	69.5	*l* [c]	*d* [b]	*d*	deformed	1.0	83.0	24.9	49.0	39.5
2	19.5	3.1	*l*	*d*	61.0	0 [a]	20.6	67.4	30.0	26.0
3	66.2	*d*	*l*	*d*	62.0	*d*	82.6	*d*	39.3	*d*
4	*l*	*l*	70.4	*d*	deformed	*d*	74.4	*d*	58.0	17.0
5	25.0	*l*	*d*	*d*	84.0	*d*	89.5	58.5	46.7	8.7
6	34.2	*d*	*l*	*d*	104.9	13.2	97.8	62.8	37.0	4.9
7	81.0	*d*	*d*	*d*	0	0	88.5	66.4	27.5	19.5
8	*l*	34.6	*d*	*d*	71.4	0	82.5	61.7	*d*	1.0
9	*l*	*d*	*d*	*d*	30.6	0	71.0	29.6	48.0	8.5
10	*l*	38.0	*l*	*d*	0	0	*d*	43.0	30.5	*d*
11	94.4	*d*	*d*	*d*	0	*d*	61.4	*d*	43.1	22.0
12	*l*	*d*	52.6	*d*	0	*d*	*d*	65.7	*d*	*d*

a the shoot alive; still buried in the husk.
b dead.
c lost.

TABLE II.—*Arbitrary values of data from Table I.*

Nut No.	Husked nuts.		One-fourth husked nuts.		Unhusked Nuts.					
					Top down.		Side down.		Top Up.	
	Dry.	Green.	Dry.	Green.	Dry.	Green.	Dry.	Green.	Dry.	Green.
1	4	*l* [a]	*d* [b]	*d*	0 [c]	0	2	0	0	0
2	0	0	*l*	*d*	4	0	0	4	0	0
3	4	*d*	*l*	*d*	4	*d*	2	*d*	0	*d*
4	*l*	*l*	3	*d*	0	*d*	3	*d*	5	0
5	0	*l*	*d*	*d*	2	*d*	2	5	0	0
6	0	*d*	*l*	*d*	1	0	1	4	0	0
7	2	*d*	*d*	*d*	0	0	2	4	0	0
8	*l*	0	*d*	*d*	3	0	2	4	d	0
9	*l*	*d*	*d*	*d*	0	0	3	0	0	0
10	*l*	0	*l*	*d*	0	0	*d*	0	0	*d*
11	*l*	*d*	*d*	*d*	0	*d*	4	*d*	0	0
12	*l*	*d*	5	*d*	0	*d*	*d*	4	*d*	*d*

a 1 = lost.
b d = dead.
c 0 = below 50 centimeters in height.
Value for figures, see text pages *12 and 13*.

TABLE III.—*Summary of Table II*[1] *showing the frequencies under the different germination grades.*

Germination grade.	Husked nuts.		One-fourth husked nuts.		Unhusked nuts.					
					Top down.		Side down.		Top Up.	
	Dry.	Green.	Dry.	Green.	Dry.	Green.	Dry.	Green.	Dry.	Green.
1	1				1		1			
2	1				1		5			
3			1		1		2			
4	2				2		1	5		
5			1					1	1	
0	3	3			7	7	1	3	9	9
d		6	6	12		5	2	3	2	3
l	5	3	4							

[1] Explanation of table on text page *88*.

The first vertical column in Table III represents what might be called the *germination grade* in this study. The actual values of the figures in this column are described in the preceding paragraph. The other figures in the table repre-

sent *frequencies* under the different *germination grades.* Discussion of the results obtained from this study are given in the following paragraphs under separate headings.

a. *Ripe and unripe nuts for seed compared.*—The results from this study confirmed conclusively the opinion of some writers, that dead ripe nuts are best for seeds. The data in Table III show that although more dry nuts than green ones were lost, the germination of the ripe nuts was about 100 per cent greater than of the green-husk nuts. The ratio of the failure in germination was about 1 to 3. In other words, more seeds with green husk failed to sprout than those with dry husk. It should, however, be borne in mind that some green-husk nuts about one-half full of water germinated, but the rate was rather slow and the percentage of viability was low.

b. *Husked and unhusked nuts compared.*—A prominent scientist once said to the writer that some one reported that a better result was obtained in germinating coconuts when a certain part of the shell was filed and made thin than when the nuts were germinated without receiving this treatment. Up to the present the writer has not found any experimental evidence supporting this opinion and according to results obtained in the present study it would seem to be not well founded, unless other special treatment was given the seeds,—as entirely burying them in moist soil or a constant supply of water. In this study some nuts were either entirely or one-fourth husked. The nuts were supposed to be one-half buried in the ground. Two entirely husked nuts (see Table I, Nos. 7 and 11) were accidentally completely buried in the ground. The result was rapid germination and vigorous growth of the seedlings. Where the nuts were not completely buried in the ground, the results observed were slow germination, and the shells of most nuts here tested, cracked. Although one or two nuts with cracked shells did succeed in germinating yet the majority failed to germinate at all. These nuts were split open, some showed that the cotyledon was rotting and others showed that the meat or endosperm, as well as the cotyledon was decaying. The causal organisms were either fungi or bacteria or both. It is, therefore, safe to recommend that unless the nuts for seed should receive special attention that would prevent the shells from cracking, they should never be husked before planting.

c. *Influence of position of nuts on germination.*—Detailed examination of the data obtained from unhusked ripe nuts reveals the fact that although germination was possible irrespective of the position of the nuts in the seed bed, yet the nuts placed lying on their side was found in the present study to be the most practical and desirable. This result is in conformity with the recommendation made by Barret (6) by Copeland (1), and by Wester (7).

The majority of the nuts placed *top down*, although they did not fail to germinate had deformed shoots. Also, the coming out of the shoot through the husk was greatly delayed. Six nuts out of twelve had either a deformed shoot or the latter was still buried in the husk when this study was ended.

The nuts that were set in the nursery bed *top up* germinated, but the rate of germination was slow,—much slower than the germination of the nuts placed *side down.* The reason for this delayed germination was that the growing cotyledon in the shell was not amply supplied with moisture. If moisture was provided at all, it was in the form of water vapor arising from the body of coconut

water in the nut and was supplied from or through the meat, or endosperm. The development, therefore, of the cotyledon, or the food-absorbing organ of the seedling from the store of food in the nut, was not as fast as it could be if the latter were amply provided with the coconut water. Numbers 1 and 5 of Fig. 2, Plate I, show the cotyledon of the germinating nuts. In No. 1 the cotyledon was just beginning to develop. The water in the nut, which at this stage was one-third sufficient to fill the cavity in the shell, could not reach the cotyledon. There is a time when coconut water is sufficiently provided for the shoot; this water helps the cotyledon to grow; it is needed in the conversion of the insoluble food into soluble form; in the translocation of this food to points where new cells or tissues are formed; and making the body of the seedling in a turgid condition. The last is a condition essential for growth. In the latter development of the seedling water is also needed in photosynthesis, in the formation of carbohydrous foods. A great deal of this water, however, comes from the soil and is absorbed by the roots and not by the cotyledon or foot.

The most ideal position of the nuts for germination in the seed bed as already stated, is *side down*. The results of this study are summarized in Table III where the highest percentage of germination was obtained with the nuts lying on their *side*. The most rapid germination was also observed among the nuts in this position. As shown in Table III and according to *germination grade*, eight ripe nuts out of twelve tested obtained a grade beyond passing (or germination grades 1, 2 and 3). Only three nuts placed *top down* obtained the *passing mark*, while those that were placed *top up* made no *passing mark* at all. These results show conclusively the advantage of placing the nuts *side down* over placing them *top down* or *top up*. An explanation of this advantage may be found in the fact that when the nuts are placed on their side, the growing cotyledon can reach and absorb the water or liquid in the shell and the sprouting shoot finds it rather easy to push its way through the thin layer of husk composed of loosely connected fibers, near the top end of the nut. The little difficulty the shoot might encounter in passing through this portion of the husk may be removed, *not* by taking off all the husk or part of the husk as tested in the present study, but by slicing off, as recommended by Copeland, a portion of the husk in this case is near the top end of the nut, to take off the hard surface of the husk; this would diminish the amount of friction that might be encountered by the shoot in coming out of the husk.

d. *Time to transplant seedling as indicated by the meat.*—An attempt will be made here to explain the desirability of transplanting coconut seedlings before they develop shoots to height of 30 centimeters. This explanation will be based mainly on the thickness of the meat or on the amount of food still left in the endosperm for use of the growing seedling. Why ready food is needed by the seedling, at least during the first few days after transplanting, is probably well understood.

Irrespective of size of the shoot, this food is needed by the seedling because the roots of the latter are not yet established in the soil. It requires about a week, if atmospheric and soil conditions are favorable, or longer if not favorable, before the roots can in moderation properly absorb water and dissolved minerals from the soil. The roots grow rather slowly especially if they are disturbed in their connection with the soil. In Laguna the roots grow, on the average, about 3.02 millimeters a day (*1*). It is then imperative that a certain amount of food be supplied the shoot and the root for maintenance and growth, while the shoot

and the root are unable to perform their respective functions of photosynthesis and absorption of soil water.

The nuts in this study were split open about the end of the fifth month in the seed bed. Accurate observations were made of the apparent condition of the meat in the shell. The important points observed may be summarized as follows:

1. The rate of absorption of food from the endosperm, judging by the amount of meat left after a period of germination, seems to depend not so much upon the duration of germination period as on the vigor of the seedling. The nuts were put in the seed bed at the same time and they were split within the same hour; the degree of development of the shoot seems to be correlated with the amount of food absorbed by the cotyledon from the endosperm. The vigor or size of the shoot or plumule depends upon the external climatic and soil conditions present during germination and upon the amount of liquid food supplied to it by the cotyledon from the endosperm, which, in turn, depends upon the degree of development of the cotyledon. The rate of growth of the cotyledon depends upon the amount of liquid materials supplied to it from the nut, which in turn again depends partly upon the position of the nut during germination; amount of water absorbed by the roots from the soil; and upon some unknown conditions.

2. The right time to transplant coconut seedlings as indicated by the meat content in the nut, seems to be when the shoot or plumule is from 15 to 30 centimeters in height. Copeland seems inclined to recommend the 15-centimeter height for transplanting. At this stage of the development of the seedlings the endosperm is still very thick. Observations made in this study showed that when the plumule was about 30 centimeters long, the food content of the endosperm was still large. When the plumule reached a height of about one meter, the endosperm was almost entirely absorbed by the cotyledon. Therefore, unless *absolutely necessary*, as when the field is not yet ready for planting or the seedlings are intended for filling out vacant hills in the field, the seedling should never be allowed to develop a shoot as long as one meter.

IV. SUMMARY OF CONCLUSIONS

The present paper is based on results obtained from a set of experiments carried out by a class on Oil Plants in this College. The number of the nuts used was small but the results obtained are fairly reliable and conclusive and in conformity with the belief given by some writers of authority on the subject. The following points may be considered fairly well established:

1. Dead ripe nuts for seed are superior to nuts at any other stage of ripeness or development. In case of *absolute necessity* green-husk nuts may be used for seed. The water in the nuts must, however, shake readily.

2. Unless the nuts for germination are to be buried in the soil or are to be amply watered, partial or complete husking is undesirable. The shell cracks quite easily when the nut is husked, and is usually the cause of most failures of nuts to germinate or of later death of the seedlings.

3. The best position for placing the nuts is *on the side*. This position is commonly followed in seed beds and also when germinated out as by the Hanging Method.

4. The desirability of transplanting the seedlings when the latter have shoots not exceeding 15 centimeters, as recommended by Copeland, or 30 centimeters as found here possible, lies in the facts: (1) that the meat content of the nut at this time is plentiful, (2) the roots are short and (3) the shoot is also short.

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ALUMNI AND COLLEGE NOTES

Toribio Vibar, '12, a university fellow in crop production, is now studying for the degree of Doctor of Philosophy in Agronomy at the University of Illinois. He writes that he completed all requirements except the thesis, and that he expects to return in August of this year.

Edgar M. Ledyard, '13, is at present Director of the Agricultural Department of the United States Smelting, Refining, and Mining Company. He obtained the degree of Master of Science from the University of California in 1915, and has been in his present position since then. Mr. Ledyard was one of the first members of the faculty of this College.

Eladio Sablan, '14, is Assistant Agronomist in charge of Fiber Investigations in the Bureau of Agriculture. Mr. Sablan was recently married to Miss Encarnación Santana of Pasig, Rizal. Mrs. Sablan is a senior student in pianoforte in the Conservatory of Music of the University of the Philippines.

Elias H. Pañganiban, '15, a special fellowship student of the University, in Chemistry, is now attending Cornell University. His present address is 123 Quarry St., Ithaca, New York, U. S. A.

At a special meeting of the College of Agriculture Alumni Association held in Los Baños College on December 14, 1922, the association unanimously passed a vote of congratulations to its President, Professor Inocencio Elayda, M. S. '16, now Director of Extension, for his success in bringing about a closer coöperation between the different farmers in the province of Laguna as a result of the first Laguna Farmers' Day held in the College of Agriculture on November 30, 1922. The association also went on record in expressing its willingness to coöperate wholeheartedly with the College of Agriculture and its Extension Agency to make future farmers' days successful.

The College of Agriculture exhibits at the University Day held in Manila on December 12, 1922, attracted quite an attention of the visitors. Mr. Pedro David, '19, of the Agronomy Department, was in charge of the exhibits. He was assisted by Mr. Felix Esguerra, '22, of the Extension Service of the College.

Hilarion G. Henares, B. S. C. E. '19, a graduate of our College of Engineering, and now employed as instructor in Sugar Chemistry of this college, was recently elected member of the College of Agriculture Alumni Association. Mr. Henares was a pensionado from the College of Engineering in the United States

and specialized in Industrial Engineering. He graduated from the University of Illinois with the degree of Bachelor of Science in Mechanical Engineering in 1921. After graduation, he went to Louisiana State University to specialize in Sugar Chemistry. He has had an extensive practical training in Factory Management, and on his return, a number of months ago, he was detailed to the College of Agriculture to complete the Sugar Mill which was christened during the Farmers' Day on November 30, 1922.

Arsenio Goco, '17, is now starting citrus and truck farming in Salawag, Das Mariñas, Cavite. He informs us that there are still several hundreds of hectares of Friar Lands available near Manila. These lands range from one hundred to two hundred pesos a hectare, payable in installments for a period of nine years. Mr. Goco is also an employee of the Bureau of Agriculture.

Mariano E. Gutiérrez, '17, writes that he is "still alive," and is working gradually for his own "economic independence". He is at present Chief Agricultural Assistant, and his present address is Pikit, Cotabato.

Eduardo Quisumbing, '18, a university pensionado, specializing in Botany (Morphology and Ecology) in the University of Chicago, is a candidate for Doctor of Philosophy, which degree he expects to obtain very soon. He obtained his Master of Science in the same university in 1921. He has been elected to active membership in the Society of the Sigma Xi, Chicago Chapter, an honorary scientific fraternity. Mr. Quisumbing is also a member of a number of other organizations, among which are The Botanical Society of America, The American Genetic Association, and the American Association for the Advancement of Science.

Melecio M. Manio, '19, who was formerly a Technical Assistant and Deputy Provincial Governor of Lanao, is now teaching in the Provincial High School of Nueva Ecija. His present address is San Isidro, Nueva Ecija.

Domingo S. Baybay, '21, is with the Bureau of Agriculture, stationed in La Carlota, Negros Occidental. He is in charge of the fiber cultures in that station.

Moises S. de Grano, '21, is now Technical Agricultural Assistant in Butuan, Agusan. In that capacity, he has the opportunity to travel throughout Agusan. He writes in part as follows:

> "The travelling official here should always be on the alert in order to make his trips on schedule. There is no provincial road, but the Agusan River serves as such. In going around the province, the traveller should provide himself with enough food, for in the remotest parts of Agusan one cannot buy anything except camote, and, in some cases, not even this could be bought."

Baltazar Corcino, '22, is at present a teacher in the provincial High School of Capiz.

Agapito E. Buenaventura, '22, is at present an instructor in Animal Husbandry and Horticulture in the Catarman Agricultural School, Catarman, Samar. He writes that he is making a success of his budding work on citrus and other plants.

"The Ranchers' Club," an organization composed of students majoring in Animal Husbandry, gave its first program on December 14, 1922, at the New Animal Husbandry Building. The program consisted of music and talks given by some of the members of the Animal Husbandry staff. In connection with the program, the members enjoyed a little dinner "on banana leaves". The affair was marked with a brilliant spirit of coöperation among the members, all of whom were kept busy by Ranchers Manuel, '24, and Limuaco, '24, who were in charge of the preparations of the dinner and of the table respectively. Some of the members of the Animal Husbandry Staff gave talks and pledged to help the club in order that the objects for which it has been organized may be realized. There was also music which added a lot to the excitement of the crowd. The party disbanded about 9:30 in the evening and everybody thought that no party could have been more successful than this. Daniel B. Pena, '22, is the Governor of the Club, and Dr. F. M. Fronda, a member of the Animal Husbandry teaching staff, is the Adviser.